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U.S. PATENT APPLICATION

for

PUMP

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PUMP

BACKGROUND OF THE INVENTION

[0001] The present invention relates generally to the field of fluid handling systems. More specifically, the present invention relates to multi-stage fluid pumps, as well as the individual stages of such pumps.

[0002] Multi-stage fluid pumps are known for use in fluid handling systems. Such pumps are used to raise the pressure of a fluid (water, oil, etc.) for purposes such as pumping, or causing the bulk transfer of such fluids. Multi-stage pumps are often used in piping systems to move fluids through such piping systems.

[0003] Multi-stage pumps raise the pressure of the fluid at discrete steps or stages within the pump, i.e. at each stage within the pump, the fluid experiences an increase in pressure. The total increase in pressure throughout the pump is the net gain of pressure at the discrete steps. The pump causes a pressure differential between the fluid inlet (typically at a relatively low pressure) and the fluid outlet (typically at a relatively high pressure).

[0004] Multi-stage pumps may use a series of discrete modules, units, or stages to create the pressure differential. When a series of discrete modules is used in a multi-stage pump, the modules located near the fluid outlet are typically at a higher pressure than the modules located near the fluid inlet. Should any of the higher pressure modules leak or otherwise allow the fluid out of the normal fluid handling path, the high pressure fluid will naturally seep or flow back towards the lower pressure modules. For example, a multi-stage pump will have a series of modules. Each module may have an outer casing contained within an outer casing of the pump. Should fluid leak out of a module, the fluid will be trapped between the module casing and the pump outer casing. As described

above, the higher pressure fluid, trapped between the two casings, will naturally flow towards a region of lower pressure (i.e. toward the fluid inlet). Thus the lower pressure modules experience a pressure gradient across their casing. The higher pressure fluid which has leaked out is pressing on the outer casing, while lower pressure fluid from the inlet is pressing from the inside on the outer casing. A high pressure gradient could cause the module to implode or otherwise fail. The failure modes become more acute when pumps are required to create large pressure rises.

[0005] Accordingly, it would be advantageous to provide a fluid pump and/or module which would resist such failure modes. It would further be advantageous to provide a fluid pump and/or module which could resist harmful effects resulting from leaks or other operational inaccuracies. It would further be advantageous to provide a relatively simple and cost effective method of repairing existing pumps and/or modules to correct such problems.

[0006] It would be desirable to provide a pump which provides one or more of these advantageous features. The techniques below extend to those embodiments which fall within the scope of the appended claims, regardless of whether they provide one or more of the above-mentioned advantageous features.

SUMMARY OF THE INVENTION

[0007] One embodiment of the present invention relates to a pump. The pump includes a housing, a pump inlet, and a pump outlet. A drive shaft is provided within the housing, and multiple stages are provided within the housing. Each stage includes a body having a fluid inlet and a fluid outlet. The body has an interior volume between the fluid inlet and the fluid outlet, and an impeller provided in the interior volume, coupled to the drive shaft. The body further includes a vent allowing fluid

communication between the interior volume and a volume outside of the body.

[0008] Another embodiment of the present invention relates to a pump including a pump casing, a shaft provided within the pump casing, and a plurality of fluid handling units. The fluid handling unit includes a housing, and a wall provided within the housing, the wall having a first surface and a second surface. The wall separates the housing into a first volume associated with the first surface and a second volume associated with the second surface. The wall is configured to allow the passage of a fluid from the first volume to the second volume. A vent is provided in the housing, in fluid communication with the first volume or second volume, and a volume external of the housing. The pump further includes an impeller disposed in the first volume, coupled to the shaft.

[0009] Another embodiment of the present invention relates to a method of repairing a pump. The pump has a relatively low pressure fluid handling module, and a relatively high pressure fluid handling module. The low pressure module and the high pressure module each have an outer casing. The method includes venting the outer casing of the low pressure fluid handling module.

[0010] Another embodiment of the present invention relates to a module for use in a fluid handling system. The module includes a housing, a wall provided within the housing having a first surface and a second surface. The wall separates the housing into a first volume associated with the first surface and a second volume associated with the second surface. The wall is configured to allow the passage of a fluid from the first volume to the second volume. The module further includes a vent provided in the housing, in communication with either the first volume or second volume, and a volume external of the housing.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] FIGURE 1 is an front plan view of a multi-stage pump according to an exemplary embodiment;

[0012] FIGURE 2 is a cross sectional view of the pump shown in FIGURE 1, taken along the line 2-2;

[0013] FIGURE 3 is a cross sectional exploded view of a portion of a stage of the pump shown in FIGURE 2;

[0014] FIGURE 4 is a cross sectional view of the pump shown in FIGURE 2, taken along the line 4-4;

[0015] FIGURE 5 is a cross sectional view of the pump shown in FIGURE 2, taken along the line 5-5;

[0016] FIGURE 6 is a cross sectional view of the pump shown in FIGURE 2, taken along the line 6-6;

[0017] FIGURE 7 is a cross sectional view of the pump shown in FIGURE 2, taken along the line 7-7;

[0018] FIGURE 8 is an exploded perspective view of a stage according to an exemplary embodiment; and

[0019] FIGURE 9 is an exploded perspective view of the stage shown in FIGURE 8.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0020] Referring to FIGURE 1, an exemplary embodiment of a pump 10 is shown. Pump 10 may be used for fluid handling, pumping, or causing the bulk transport of a fluid 12. Pump 10 may be a submersible pump as shown (i.e. the entire pump is submersed in the fluid to be pumped) or the pump may also be an "in-line" pump (i.e. fluid enters and exits the pump via piping or other such structures). Pump 10 includes a fluid inlet 14 and a fluid outlet 16. Fluid entering inlet 14 is generally at a lower pressure than fluid exiting outlet 16. Fluid enters the inlet 14 of the

pump 10 from a body of fluid to be pumped, and exits via piping or other such structure such as outlet 16. The pressure rise of the fluid imparted by the pump 10 results in the bulk transfer of fluid 12.

[0021] Referring to FIGURE 2, the pump 10 is shown in cross-section, illustrating multiple stages 18 of the pump 10. The stages 18 collectively raise the pressure of fluid 12 from the inlet 14 to the outlet 16. Each stage 18 raises the pressure of fluid 12 a discrete amount. In an exemplary embodiment, each stage is capable of raising fluid pressure by twelve to nineteen pounds per square inch (12-19 psi). The discrete pressure rises from individual stages 18 results in an overall rise in the pressure of fluid 12 from inlet 14 to outlet 16. The configuration described above for pump 10 is referred to as a "multi-stage" pump.

[0022] Stage 18 is shown in greater detail in FIGURE 3. Stage 18 is preferably a discrete unit, module, or component which includes a housing, or outer casing (shown as body 20), a division or partition (shown as wall 22), an impeller 24, first and second plates 26 and 28, and a vent 30.

[0023] As shown in FIGURES 3, 8, and 9, the body 20 may be a generally cylindrical component and preferably is a housing or outer casing which defines the outer periphery of stage 18. The body 20 typically is dimensioned to allow the body 20 to fit inside an outer casing 32 of the pump 10 as shown in FIGURE 2. In an exemplary embodiment, the body 20 has an outer diameter of 3.1 inches (FIGURE 3). However, the body 20 may have an outer diameter in the range of 2.0 and 3.5 inches. In an exemplary embodiment, body 20 has a wall thickness 34 of 0.16 inches. However, body 20 may have a wall thickness 34 of between 0.14 and 0.17 inches. The body 20 generally defines an internal cavity 36. Referring back to an exemplary embodiment shown in FIGURES 3, 8, and 9, the body 20 is preferably constructed from plastic. However, the body 20 may be constructed from a variety of other

materials such as plastics, polymers, composites, metals, metal alloys, etc.

[0024] As shown in FIGURE 3, the stage 18 further includes a partition or division shown as wall 22. This wall 22 is provided in the cavity 36, and generally extends across the diameter of the body 20 to define a first volume 38 and a second volume 40 within the cavity 36. The wall 22 is provided with an aperture 42 centrally located with respect the body 20, and the aperture 42 is configured to allow the passage of a shaft 44 of the pump 10 through stage 18, as will be described further below.

[0025] Fluid passageways 46 (shown as apertures) are provided around the periphery where the wall 22 and body 20 intersect. The passageways 46 provide a path for fluid to travel between the first volume 38 and the second volume 40 as will be discussed in further detail below. As shown in FIGURE 4, the passageways 46 are slanted vias or ducts which allow a fluid to pass from first volume 38 to second volume 40. Alternatively, the fluid passageways may be any other type of connection, gap, pass through, or slit which provides fluid communication between the first volume 38 and the second volume 40.

[0026] The stage 18 may additionally include a plurality of vanes 48. As shown in FIGURES 7 and 9, vanes 48 are preferably provided on the wall 22 in second volume 40.

[0027] Referring back to FIGURE 3, the stage 18 further includes impeller 24 which is preferably provided in the first volume 38, coupled to the shaft 44 of the pump 10. The rotation of the shaft 44 causes rotation of the impeller 24. The impeller 24 includes blades 50 coupled to the shaft 44.

[0028] A first plate 26 is provided on a first end of body 20, and a second plate 28 is provided on a second end of body 20. In an exemplary embodiment, first plate 26 and second plate 28 are provided on body 20 by a press fit engagement. Alternatively, first and second plates 26 and

28 may be provided on body 20 using a variety of coupling techniques, including adhesives, co-molding, fasteners such as screws and the like, etc. First and second plates 26 and 28 are provided with aperture 52 to allow passage of fluid into and out of the stage 18, and to allow passage of the shaft 44 to adjacent stages.

[0029] As shown in FIGURES 8 and 9, the vent 30 (shown as a notch) is provided in an outer wall 54 of the body 20. The vent 30 provides fluid communication between the cavity 36 and the exterior of body 20. As shown in FIGURE 2, the vent 30 provides fluid communication between the first volume 38, and a gap 56 between the body 20 and the casing 32. Alternatively, the vent may be a notch, opening, gap, aperture, fluid passage, etc. which allows fluid to pass through the outer wall of the body.

[0030] The operation of the stage 18 and pump 10 is as follows as seen in FIGURE 2. Fluid 12 enters the pump 10 via the inlet 14, passes through the aperture 52 in the first plate 26, and into the first volume 38 which is also occupied by the impeller 24. As discussed above, the impeller 24 rotates in conjunction with the shaft 44. As shown in FIGURE 5, the rotation of the blades 50 of the impeller 24 causes the fluid to be forced radially outwardly within the first volume 38. Once fluid 12 has been forced toward the outer periphery of first volume 38, the fluid passes into the second volume 40 via the passages 46, as shown in FIGURES 4 and 6. As shown in FIGURE 7, the vanes 48 direct fluid 12 back towards the center of second volume 40. Once back to the center, fluid 12 then passes out of the stage 18 via the aperture 52 in second plate 28, and then into the next stage where the process is repeated.

[0031] Referring back to FIGURE 2, it will be appreciated that as fluid passes from stage to stage, and flows from the inlet 14 to the outlet 16, the fluid 12 experiences a rise in pressure. According to one exemplary embodiment of pump 10, the pressure rise may be 19 psi. Thus, fluid 12

at each successive stage 18 in a multi-stage pump is at a higher pressure than the fluid at a previous stage.

[0032] As described above, the pump 10 may be constructed by providing several stages proximate each other in order to create the necessary pressure rise for fluid 12. However, the fluid 12 may possibly leak from stage 18 for a variety of reasons. For example, fluid 12 may leak from each stage 18 due to gaps between the body 20 and the first plate 26, or gaps between the body 20 and the second plate 28. Fluid 12 is more likely to leak out of the higher pressure stages 18 within a multi-stage pump 10.

[0033] Once fluid 12 has leaked out of a stage 18, it will be between body 20 of stage 18 and casing 32 of pump 10. Higher pressure fluid will naturally tend to flow back towards lower pressure areas. In a multi-stage pump 10, higher pressure areas will be the stages closer to the outlet 16, whereas lower pressure areas will be found in stages closer to inlet 14. Thus fluid 12, between body 20 and casing 32, will tend to flow back toward inlet 14. As fluid 12 approaches the inlet, a pressure gradient may occur between the fluid exterior of body 20, and fluid 12 interior body 20. This pressure gradient may be sufficient to cause the body 20 to crack, implode, or otherwise fail. Typical pressure gradients that are expected to cause failure are believed to be in the range of 300-400 psi. However, the vent 30 provided in body 20 prevents the creation of a dramatic pressure gradient. The vent 30 allows a limited amount of the high pressure fluid, that is between the casing 32 and the body 20, into the cavity 36 of body 20. The vent 30 permits the partial equalization of pressure between the higher pressure fluid that is external of body 20, and the lower pressure fluid that is internal of body 20. Partially equalizing the pressure between the fluid internal the body 20, and fluid external the body 20, thereby reduces the pressure on the body, and reduces possible failures of the body integrity. In an exemplary

embodiment, venting portion 30 may have a cross-section area of at least 0.3 square inches. Alternatively, venting portion may have any shape, configuration, or cross-sectional area sufficient to provide sufficient pressure relief of a pressure gradient across a stage body. It should be appreciated that pump losses (i.e. reductions in pumping efficiency) lower as the cross-sectional area of the venting portion decreases.

[0034] It should be appreciated that the teachings described above apply not only to the construction and design of a multi-stage pump, but also to repairing an existing pump. Such a method would include providing the venting portion 30 by a variety of methods including drilling, cutting, notching, or otherwise providing a relief, aperture, venting portion, or hole in the body 20 of each stage 18.

[0035] It is also important to note that the construction and arrangement of the elements of the stage and pump shown in the preferred and other exemplary embodiments is illustrative only. Although only a few embodiments of the present inventions have been described in detail in this disclosure, those skilled in the art who review this disclosure will readily appreciate that many modifications are possible (e.g., variations in sizes, dimensions, structures, shapes and proportions of the various elements, values of parameters, mounting arrangements, use of materials, colors, orientations, etc.) without materially departing from the novel teachings and advantages of the subject matter recited in the claims. Accordingly, all such modifications are intended to be included within the scope of the present invention as defined in the appended claims. The order or sequence of any process or method steps may be varied or re-sequenced according to alternative embodiments. In the claims, any means-plus-function clause is intended to cover the structures described herein as performing the recited function and not only structural equivalents but also equivalent structures. Other substitutions, modifications, changes and omissions may be made in the design,

operating conditions and arrangement of the preferred and other exemplary embodiments without departing from the scope of the present inventions as expressed in the appended claims.